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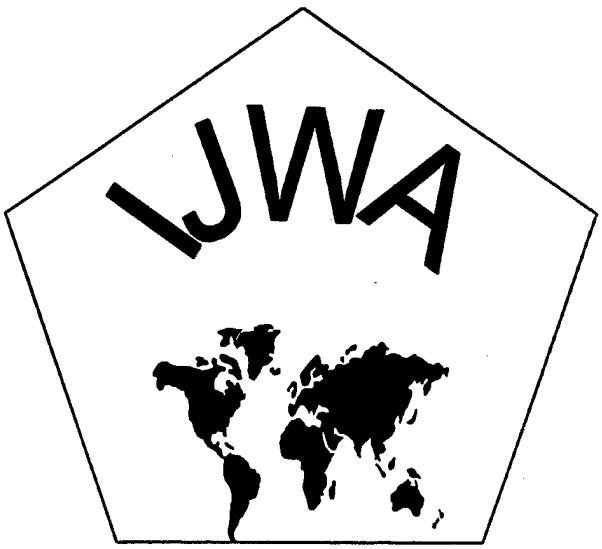
ANALYSIS OF THE OBJECTIVE DATA FROM FLEET BATTLE EXPERIMENT HOTEL



Nelson Irvine

January 2001

The Institute for Joint Warfare Analysis
Naval Postgraduate School
Monterey, California

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13. ABSTRACT (Maximum 200 words.)

This is a report of the objective data collected during FBE H. Most of these data were collected electronically from the systems that compose and support the Digital Fires Network (DFN). Sources of data include: LAWS, GISRC, RPM, JTW and DTF. These data allow the quantitative characterization of the Time Sensitive Target (TST) engagement process.

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1. Principal Findings.

This section lists the principal findings gleaned from an analysis of the FBE H objective data. The findings are divided into three groups, the groups are:

Operational. Findings related to participant actions.

Experimental Methodology. Findings related to the way the experiment was designed and the way the experimental procedures were defined.

Process. Findings related to the experiment system architecture and its operation.

1.1. Operational Findings.

Sixty-three percent of TST target nominations were engaged. This result is similar to that in FBE F and FBE G.

A plurality of targets were engaged with LASM (46 percent).

The San Jacinto conducted 79 percent of all engagements.

A high percent of missions (including both TST and MTO) called for engagements with multiple rounds (45 percent) but in only three cases were the rounds given individual aim points. Of the eight LASM missions that called for multiple rounds, only three cases fired the required number of rounds.

A large fraction of TST missions (30 percent) were fired unmensurated.

For GISRC the median interval from target acquisition to transmission of the target nomination to LAWS and JTW was 5.1 minutes (mean time was 8.6 minutes).

For JTW the median interval between receipt of the mensuration request and transmission of the mensuration target position was 4.5 minutes (mean time was 7.9 minutes).

For LAWS the median interval between receipt of the target nomination at LAWS until the issuance of the fire when ready command was 14.5 minutes (mean time was 22.6 minutes).

For RPM the median time from receipt of a TLAM or TTLAM route request until transmission of the completed route for a TST target was 80 seconds (mean 79.9seconds).

Few, if any, targets with dwell times of 30 minutes or less were successfully engaged.

BDA data, as manually entered into the DTF, were often inconsistent with the LAWS engagement information.

1.2 Experiment Methodology Findings

The rate of target nomination, determined from the nominations that appear in LAWS, was low (24.8/day including both MTO and TST nominations). But there is evidence that a significant number of nominations did not reach LAWS (see Section 1.2).

Calculated target Not Later Than (NLT) times are often not realistic. NLT times need to be determined based on the knowledge of the state of individual targets.

The San Jacinto engaged 48 percent of its MTO targets. MTO targets were often furnished with no or erroneous and unmensurated target positions. The MTO engagements were fired unmensurated. There was no interaction between the MTO and TST tasking.

1.3 Process Findings

Of those nominations logged as sent by GISRC, 30 percent do not appear in LAWS. Of those nominations logged by JTW, 44 percent do not appear in LAWS. There were five instances where JTW reported a target mensurated but the mensurated data do not appear in LAWS. A mechanism to verify the receipt of nominations and other messages within the DFN is required.

For RPM the median time from receipt of a TLAM or TTLAM route request until transmission of the completed route for MTO missions was median 177.5 seconds with a mean of 321.5 seconds. The corresponding figures for TST targets were 80 and 79.9 seconds. The MTO mission times were much higher because of the near simultaneous request for many TTLAM routes resulting in the queuing of requests, route requests remained in the queue for a maximum of 960 seconds. A single RPM workstation is inadequate for high engagement intensity.

The great majority of weapon firings (at least 77 percent of the engagements) were not sent to, and not fired, flown out, or impacted in JSAF. This had a significant impact on the engagement timeline and utilization of assets due to the delay in target assessment and BDA.

Despite an effort to introduce time synchronization to FBE H there is evidence synchronization was not achieved. This synchronization is necessary to characterize DFN latencies and construct engagement timelines

Latencies in the transmission of: nominations to LAWS and JTW, UAVSim video to GISRC and updates among the LAWS nodes, at times, significantly affected engagement timelines.

DTFs do not log the time and source of each update. The DTFs do not contain target engagement data (e.g. weapon employed, time of fire, time of impact).

2. TST Engagements

In FBE F and G the missions that appeared in the LAWS Mission Coordination: Fires display were limited to TST missions. In FBE H, the LAWS data included some MTO targets in addition to the TST targets. In many cases, a target was identified as an MTO target in the LAWS remarks, in other cases the MTO nature of the target was deduced from the fact it was nominated by the San Jacinto LAWS workstation rather than a GISRC work station. The following discussion refers only to the TST targets unless otherwise stated.

Table1 summarizes the engagement data for TSTs in Phase I of FBE H. The nomination rate in FBE H was low with an average of 19 nominations per day (including the MTO nominations the value goes up to 24.8 nominations per day) compared to 40.6 nominations per day in FBE G. Of the 76 TST targets nominated, 48 (63%) were engaged. The engagement rate in FBE H is similar to that in FBE F (53%) and FBE G (56%).

The nominations examined are those that appear in the LAWS Mission Coordination: Fires display. As will be discussed later (see Sections 5.2 and 7.1), there is evidence that many nominations do not appear in LAWS. A small number of nominations that were described as test cases or inadvertent duplicates have been excluded from the analysis.

The breakdown of weapon types assigned to the TST engagements are listed below:

LASM	45.9%	FASM	2.1%
ERGM	31.3%	TACAIR	2.1%
TTLAM	18.8%		

The choice of weapons shifted dramatically with respect to FBE G. In particular, the TST targets against which TTLAM/TLAM were employed dropped from 44.9 % in FBE G to 18.8 % in FBE H. In FBE G, LASM was employed against 15.1% of the TSTs while in FBE H the corresponding figure is 45.9%. The differences in employment extend beyond these numbers. In FBE G many of the TTLAMs were fired into loiter boxes (35%), in FBE H, however, only TTLAM one targeted to a loiter box. In FBE H, all LASM missions specified a single missile, In FBE H eight of the 21 (38%) LASM TST missions fired called for multiple projectiles.

TABLE 1

FBE H TST ENGAGEMENT DATA

DATE	NOMINATIONS	ENGAGED	ERGM		LASM		TTLAM			TLAM	FASM		TAC	TOTALS
PLATFORM			SAN	DEYO	SAN	DEYO	SAN	DEYO	ALE		SAN	DEYO		
28-Aug	18	12	0	0	9	0	2	1	0	0	0	0	0	
29-Aug	9	4	0	0	1	0	2	0	0	0	0	1	0	
30-Aug	16	7	1	0	2	2	1	0	0	0	0	0	1	
31-Aug	33	25	12	2	8	0	0	2	1	0	0	0	0	
TOTALS	76	48	13	2	20	2	5	3	1	0	0	1	1	48
%		63.2	27.1	4.2	41.7	4.2	10.4	6.3	2.1	0	0	2.1	2.1	100.2

Columns

Date: Experiment date

Nominations: Total number of targets nominated

Engaged: Number of nominated targets that were engaged

ERGM - FASM: Number of engagements for a specific munition type. This is not a round count, In many missions multiple rounds were fired.

3. Nominated Targets not Engaged.

For the 28 TST nominations not engaged in FBE H, the LAWS denial codes, or remarks in the LAWS Targeting Information, provided reasons for the target rejection in eight cases (see Table 2). The remarks, in LAWS, indicate the INT rejection code was used in cases where mensuration data were not available. In three other cases, not included in the table, the INT and OLD rejection codes were applied to indicate inadvertent duplicate nominations. A consistent and standardized definition and application of LAWS denial codes is needed.

TABLE 2
REASONS MISSION WERE NOT FIRED AS INDICATED IN LAWS

LAWS CODE	REASON FOR NOT ENGAGING TARGET	# OF CASES
INT	Past Intel cutoff date	3
OLD	Target dwell time exceeded	1
TGM	Target Moving	2
NHV	Not High Value	1
	No hit Area	1

4. Multiple Round Missions.

In many FBE H engagements it was specified in the LAWS Firing Information that more than a single round was to be fired against a target. Table 3 gives the fraction of multiple round missions by weapon type. The data in the table includes both the MTO and TST missions that were fired and appear in the LAWS Mission Coordination: Fires display.

Table 3 includes 48 TST missions and 11 MTO missions. All the multiple round TTLAM/TLAM missions are MTO missions.

TABLE 3
FRACTION OF FIRED MISSIONS CALLING FOR MORE THAN ONE ROUND

WEAPON	#MISSIONS	# WITH >1 RND	%
TTLAM/TLAM	18	3	16.7
LASM	24	8	33.3
ERGM	15	14	93.3
FASM	2	1	50

4.1 Rounds Actually Fired

The LASM data are in particular illustrative of inconsistency in mission execution. Of the eight missions in which more than one round was required, there were only three cases where the requested number of rounds were fired.

In two cases, the requested LASMs were replaced, at least in part, by TTLAMs. For target number GM5032, three LASMs were specified but one LASM and one TTLAM were fired. For target number GM5031 a single LASM round was requested but a single TTLAM round was fired. This latter mission is counted as a TTLAM mission not a LASM mission.

There were also cases (GS0081 and GS0084) where more than the requested number of projectiles were fired. These could be execution errors but, more likely, represent reengagement of targets using the same target number (see Section 4.3).

4.2 Aim Points

For all the cases in which multiple rounds were fired (14 ERGM, 6 LASM, 3 TTLAM/TLAM and 1 FASM), in only three cases were different aim points used for the individual projectiles:

For target number GS0038 (an MTO target), three TTLAMs were fired at the same aimpoint one at a different aimpoint.

For target number GS0040 (an MTO target), all four TTLAMs were fired at different aimpoints.

For the GS0081 TST mission, only one LASM round was requested but 2 TTLAMs and one LASM were fired, two at one aimpoint the third round at a different aimpoint.

4.3 Multiple Rounds Engagements Result in Missing LAWS Data

LAWS permits target reengagement using the same target number, but the LAWS Mission Coordination: Fires timeline reports timeline events for only one of the projectiles. For LASM, TLAM and TTLAM firings the individual launches are listed in the Mission Coordination: TLAM table but the times of the individual launches are not reported. This may not be a serious problem where multiple rounds are requested and they are fired virtually simultaneously. It is a problem when the mission is refired after a long interval. The Missions Coordination: Fires timeline records data for only one of the firings and data for the other is essentially lost. It is proposed that a unique target number be created for each distinct weapon firing at a target. For example, if a LASM is fired at target number GS4444, which is subsequently engaged with a TTLAM, the TTLAM reengagement appear in Mission Coordination: Fires and Mission Coordination: TLAM as GS4444A.

5. Mensuration.

When mensuration data are received at LAWS, the Circular Error (CE) and Linear Error (LE) values are automatically recorded in the remarks area of the targeting information. In the case of the San Jacinto, the JTW- LAWS communication link was not functioning, therefore, the mensuration data were not transmitted in an ATI.ATR message to LAWS. Consequently, the LAWS operator manually entered mensurated coordinates and the CE/LE data. The absence of CE/LE values in the LAWS Targeting Information is taken as evidence that the target was unmensurated. Unmensurated TST missions include the following:

Of the 22 LASM missions 6 (27.3%) were fired unmensurated.
Of the 15 ERGM mission 5 (33.3%) were fired unmensurated.
Of the 9 TTLAM missions 3 (33.3%) were fired unmensurated.

Firing of TTLAMs at unmensurated targets does not necessarily represent a procedural failure in that the mensurated target position can be transmitted to the in-flight missile. But in FBE H, only one TTLAM was retargeted and it was not one of the unmensurated launches.

The great majority (82 percent) of the unmensurated firings for LASM and ERGM occurred on 31 August.

For two of the unmensurated nominations, the JTW data log sheets (see 5.1) confirm that target mensuration was not performed due to the lack of Digital Point Positioning Database (DPPDB) data.

5.1 JTW Data.

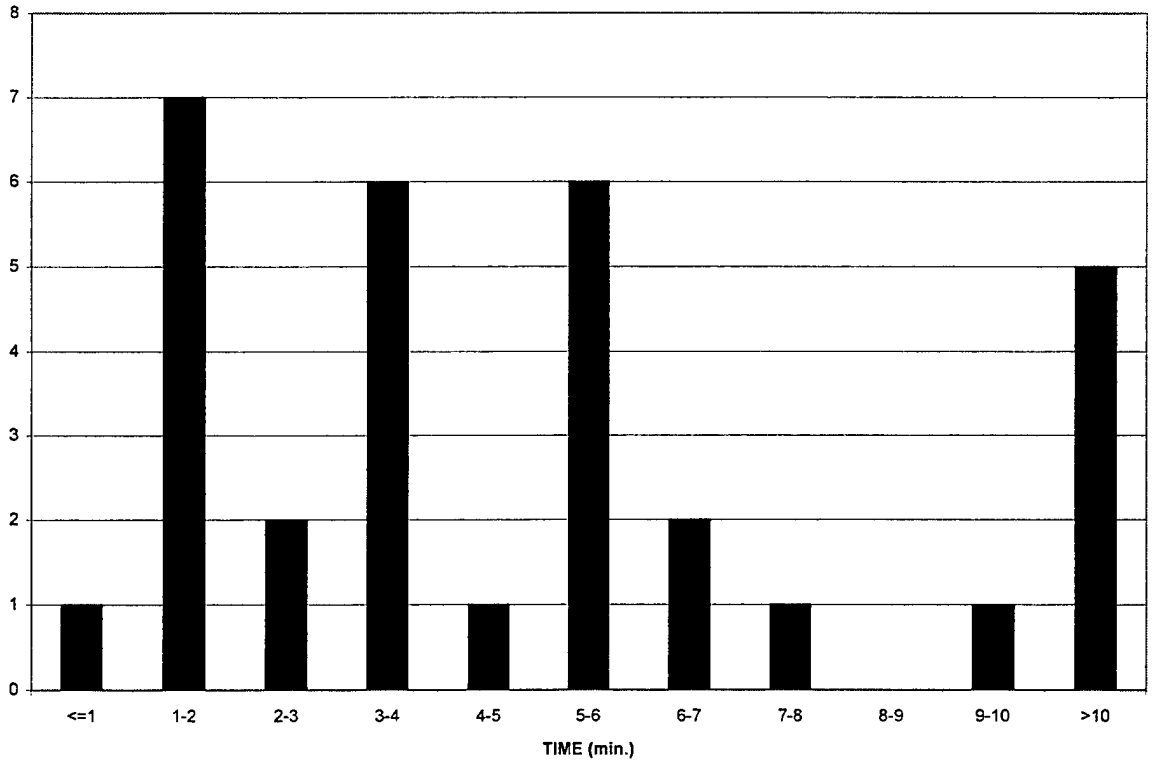
JTW data were successfully collected only on the MTW and HST. Mensuration was performed on 36 (72%) of the 50 nominations received by those two platforms. The JTW data were not automatically logged. The operator manually recorded the time the request was received from GISRC, the time the mensurated data were sent to LAWS and the actual time spent mensurating the target. In most cases where the target could not be mensurated, it was because there were no DPPDB data for the target area (this occurred for 10 nominations). Table 4 contains summary data compiled from JTW data sheets supplied by Bruce Butts (NRO). For the two platforms that supplied mensuration data, the average mensuration time from the receipt of mensuration request until the data were transmitted was 7.9 minutes similar to the average of about nine minutes in FBE G. As Table 4 shows, the average mensuration time for the MTW was 6.3 minutes with zero time in queue. But for the HST, even on days with few requests, there were significant delays in the queue (average mensuration time 3.9 minutes, average receipt to send time 8.4 minutes). The FBE H mensuration time average was somewhat reduced due to fact that on Aug 31 the HST JTW mensurated 10 targets from a single UAV image. The effect of that unusual circumstance on mensuration time is obvious in the August 31 HST data in Table 4.

Figure 1 is a histogram of the intervals measured from the receipt of the mensuration request until the transmission of the mensurated target position.

TABLE 4
JTW DATA

				RECEIPT TO SEND		MENSURATION TIME	
PLATFORM	DATE	#REQUEST	#MENSURATED	AVG	MEDIAN	AVG	MEDIAN
MTW	28	4	2	10.5	10.5	10.5	10.5
MTW	29	3	0				
MTW	30	0	0				
MTW	31	7	5	4.6	4	4.6	4
MTW	ALL	14	7	6.29	5	6.29	5
HST	28	6	5*	14	14	10	10
HST	29	6	3	33	16	8	7
HST	30	4	3	7	7	5.3	5
HST	31	20	18	3.7	3	2.3	2.5
HST	ALL	36	26	8.4	4	3.9	3
MTW,HST	ALL	50	33	7.9	4.5	4.4	4
*three of the mensurations were interrupted by briefings and are not included in the totals							

FIGURE 1
HISTOGRAM OF JTW RECEIPT OF NOMINATION TO COMPLETION INTERVAL
(33 observations)



5.2 Missing Nominations

A comparison of the 50 target nominations received by the JTWs on the MTW and HST with the target nominations reported in the LAWS Mission Coordination: Fires display shows that 22 (44%) of the JTW nominations did not appear in LAWS. Further, there were five cases where the JTW logs state the target was mensurated but the CE/LE values indicative of a mensurated target were not reported in LAWS implying the updated ATI.ATR message sent from a JTW were not received at LAWS. There is at present no mechanism to verify the receipt of ATI.ATR messages sent between GISRC, LAWS and JTW. Such a mechanism is required. Missing nominations are discussed further in Section 7.

6. Acquisition – LAWS Interval.

GISRC defines the acquisition time as the time that the GISRC operator creates a track (or updates an existing track) of a militarily significant object. GISRC automatically records and logs this event. This acquisition time is included in the ATI.ATR nomination to LAWS and is reported in the LAWS Targeting Information. In FBE H, changes to the GISRC software ensured the inclusion of the acquisition time in the ATI.ATR message, an improvement from FBE G.

Despite the attempted introduction of time synchronization for all systems for FBE H, timing problems persist. With regard to the interval between Acquisition and receipt of the nomination at LAWS (hereafter LAWS-ACQ) these timing problems were manifested in two ways:

1. For most of Phase I of FBE H (Aug 28-31), the LAWS-ACQ interval for the GM and GC nominators (GISRC MTW and Cherry Point) averages about four minutes which is consistent with time estimates of GISRC operators. The LAWS-ACQ interval for the GS and GH nominators (GISRC San Jacinto and HST) averages about one hour and four minutes. It is possible that the LAWS workstations on the HST and the San Jacinto were reset to local time for a more easterly time zone.

2. For the last part of the day on Aug 31 the LAWS-ACQ interval for several GH nominations was about 58 minutes (given the above assumption, this implies the LAWS-ACQ interval is negative for these engagements) and the interval for one nomination from GC was -9 minutes. This suggests LAWS and GISRC were out of synchronization by roughly 10 minutes.

Accordingly, in determining the values for the ACQ-LAWS interval 60 minutes was subtracted from the values for GS and GH nominations and data subsequent to the GH0225 nomination on August 31 were discarded.

For 60 TST nominations (excluding data subsequent to nomination GH0225 on Aug 31 and two outliers where the interval was greater than one hour) the mean time between

acquisition and receipt of the nomination at LAWS was 5.15 minutes with a median time of four minutes. In the LAWS data, the acquire time is reported in minutes, time of receipt at LAWS is reported to the second but that time has been rounded to the nearest minute. Table 5 below compares the data from the last three FBEs.

TABLE 5

ACQUISITION TO RECEIPT OF NOMINATION AT LAWS INTERVALS
(times in minutes)

EXPERIMENT	#OBSERVATIONS	AVG.	MEDIAN
FBE H	60	5.7	4
FBE G	36	9.1	6.5
FBE F	30	27.3	23

Even though the total number of nominations in FBE H was much smaller than in FBE G, the sample size presented in the table is larger because of the changes made to GISRC to ensure acquire time was recorded for every GISRC initiated nomination.

As will be discussed in Section 7, the event data from GISRC, available for the first time in this experiment, provided evidence that the ACQ- LAWS interval determined as above, is subject to a timing error. Nevertheless, the calculation was performed to provide a direct comparison with the data from previous experiments.

7. GISRC Data

Each GISRC workstation (San Jacinto, MTW, HST and Cherry Point) logged information for each target acquired and nominated. The GISRC data were supplied by Jim Burdell and Greg Bulla (SPAWAR). The GISRC data are not complete, particularly early in the experiment when the data logging program was being modified. The logged GISRC data contain 37 instances where nominations were sent to LAWS compared to the 76 TST nominations that LAWS actually received.

For this analysis, the first TOT time (= acquisition time), nomination time and the time nomination was sent were used to compute the interval between acquisition and nomination (ACQ-NOM), the interval between nomination and the time the nomination was sent to LAWS (NOM – SEND) and the total interval between acquisition and sending the nomination (ACQ – SEND). As Table 6 indicates, the GISRC processing time is predominately involved with the mechanics of preparing the nomination message and selecting and appending imagery to it (i.e. the NOM-SEND interval). Because the data contain outliers the median values are considered more representative.

TABLE 6
GISRC TIME INTERVALS
(times in seconds)

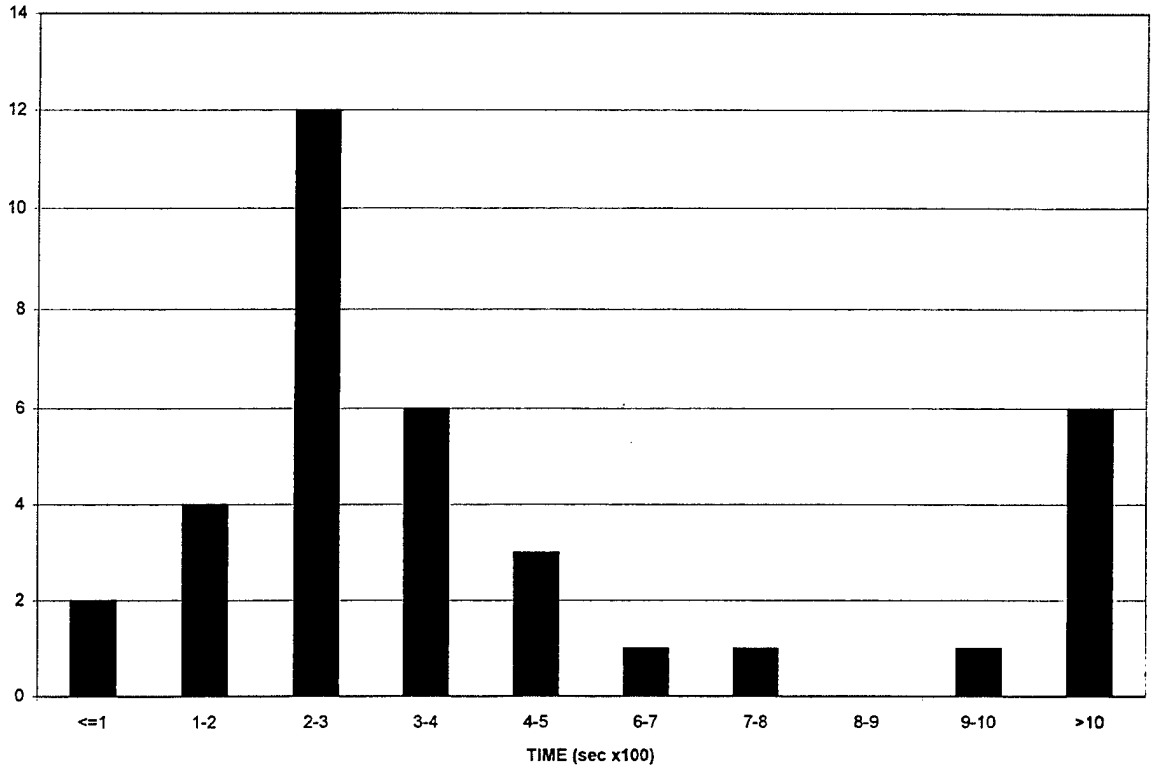
	ACQ-NOM	NOM-SEND	ACQ-SEND
# OBSERVATIONS	41	35	36
MEAN	162.98	384.14	515.56
MEDIAN	10	248	305.5

The GISRC median ACQ-SEND interval of five minutes (305.5 secs) should be compared to the value reported in Table 5 which shows the median interval between GISRC acquisition and receipt of the nomination at LAWS was four minutes. The two populations of nominations used to determine these medians are not identical so the values are not directly comparable, but it would be expected that if anything, the latter interval would be longer. Construction of time lines for several engagements showed cases for which the time that GISRC reported the nomination was sent to LAWS was about 50 seconds after the time that LAWS reported the nomination was received (one of these timelines in shown in Table 11). This appears to be another manifestation of unsynchronized clocks on different systems.

Figure 2 presents a histogram of the ACQ-SEND interval for 36 GISRC nominations.

Of the 37 cases where GISRC logged a nomination sent time (one reported an erroneous time and is not included in Table 6 or Figure 2), 11 were apparently not received by LAWS in that they do not appear in the LAWS Mission Coordination: Fires list. Again, a mechanism for confirming receipt of, and for re-sending nominations is required.

FIGURE 2
HISTOGRAM OF GISRS ACQUIRE TO TRANSMIT NOMINATION INTERVAL
(36 Observations)



8. LAWS – Fire Interval.

The LAWS timeline events relating to weapon firing are frequently missing and occasionally obviously erroneous. The transmit On call (XMT OC), and transmit when ready (XMT WR) fire commands and the Fired Report (FRD) randomly appear or are absent for the fired engagements. This was also in the case in FBE F and FBE G. Table 7 provides the statistics on the FBE H fire times in comparison with the data collected in FBE F and FBE G. The data from FBE H are distinguished by the small sample size and the absence of the high value (and probably erroneous) outliers found in the earlier experiments.

TABLE 7

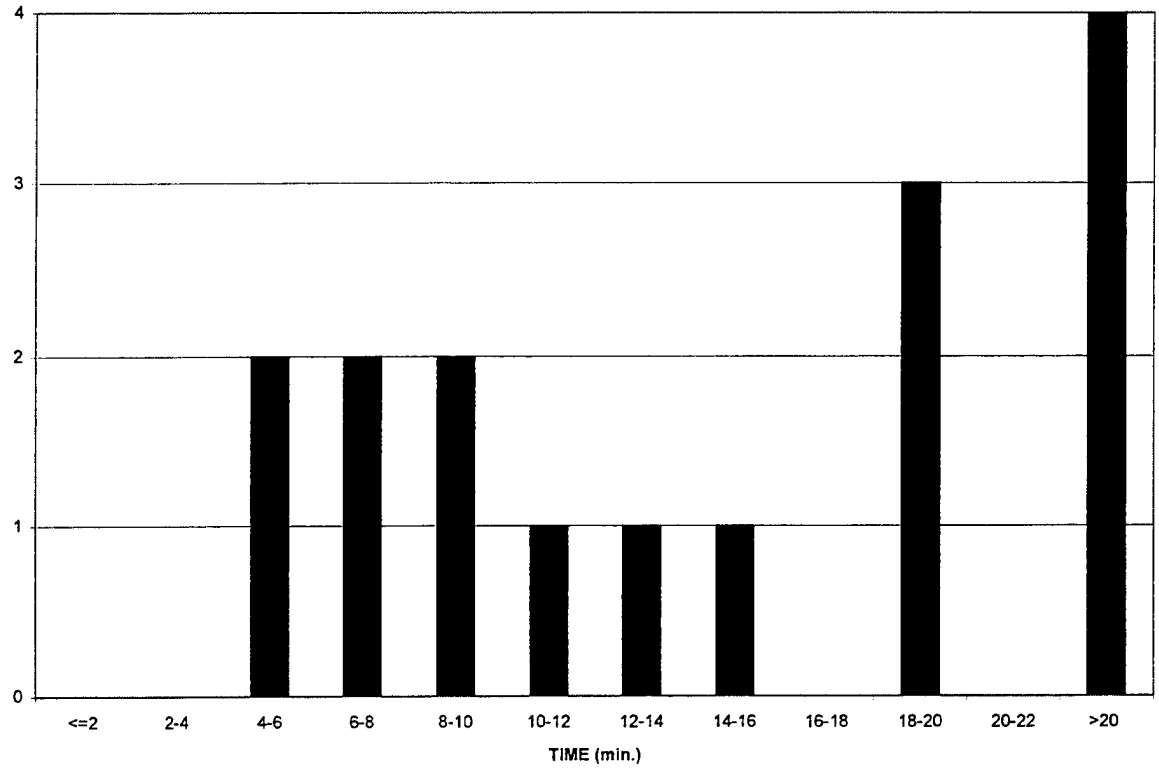
INTERVALS FROM LAWS RECEIPT OF NOMINATION TO FIRE RELATED EVENTS

	EVENT								
	OC			WR			FRD		
EXP	#OBS	AVG	MED	#OBS	AVG	MED	#OBS	AVG	MED
FBE H	10	22.3	20.5	16	22.6	14.5	11	44	48
FBE G	90	19.5	14.5	30	27	26	52	41.1	37
FBE F	NA			40	21.2	16	16	38.8	39

The events in the table are:
OC: Issuance of On Call fire command.
WR: Issuance of When Ready fire command.
FRD: receipt of Fired report.
Average (AVG) and Median (MED) times are in minutes.
The statistics reported for FBE G and FBE F exclude outlying observations where the intervals exceeded 90 minutes. The intervals between the receipt of the nomination at LAWS and the various fire related events shows no substantial change over the three experiments.

Figure 3 is a histogram of the LAWS the intervals between the receipt of the target nomination at LAWS and the issuance of the f ire when ready command.

FIGURE 3
HISTOGRAM OF THE LAWS RECEIPT OF NOMINATION TO THE FIRE COMMAND (WHEN READY) INTERVAL
(16 Observations)



9. Dwell Times.

A table of target dwell times for use in FBE H was created by Jim Burdell (SPAWAR). On nominating a target, the GISRC operator selected a target type and the dwell time for that target type was automatically entered into the LAWS nomination message. LAWS does not report the dwell time, but computes and reports a NLT time that is based on the dwell time. In this analysis, the dwell times were recovered from the reported LAWS NLT times by taking the difference between the NLT time and the time the nomination was received at LAWS. In general, these computed dwell times corresponded with the tabular dwell times, for the appropriate target types, as contained in the dwell time table. However, particularly in the first days of the experiment, it appears some of the GISRC operators were manually inserting erroneous dwell times. In particular, SCUD dwell times were correctly found to be 30 min. for August 30 and 31 but on August 28 and 29 they varied from 9 min. to 2 hrs. For these latter two days the GM nominator reported the correct value, but the GS and GH nominators did not.

10. Definition of NLT Time

As described in Section 9, LAWS calculates the NLT time by adding the dwell time to the time the nomination was received at LAWS. This NLT value is an optimistic estimate from the perspective of the shooter, in the sense that he will be led to believe the target will be engageable longer than it in fact would. Often, a better approximation to the NLT time would be obtained by adding the dwell time to the GISRC reported acquisition time. However, in those cases where the target is observed to stop and the nomination then updated, the current NLT definition is appropriate. The treatment of dwell and NLT times should be reexamined and adapted to reflect the knowledge and status of specific targets.

A separate issue is the play of dwell times in JSAF. JSAF has the capability of automatically moving or hiding a TST after the expiration of its dwell time. It should be ensured that this feature of JSAF is employed so that if projectiles are impacting after the expiration of a target's dwell time and its consequent movement out of the projectile impact area, they are not being credited with a kill.

10.1 Meeting NLT Times

Table 8 displays the engagement NLT status as a function of dwell time. That is, was the target hit within the dwell time (NLT met), was the target not hit within the dwell time (NLT not met) or is the result uncertain (NLT met?). The latter category was applied to TLAM or TTLAM launches for which the interval between the LAWS fire event and the NLT time was less than 30 minutes or ERGM and LASM launches for which that interval was less than 10 minutes. The uncertainty in the actual fire time and the projectile time of flight means it is uncertain whether the projectile would have struck the target before expiration of the dwell time. The LAWS Mission Timeline Report may report three fire related events: transmission of the On Call (OC) fire command, transmission of the When Ready (WR) fire command, and the Fired Report (FRD). Whether these data are present or not for a fired mission is unpredictable. In the case of FBE H, there are many cases where the Mission Coordination: Fires and the Mission Coordination: TLAM displays indicate the missions were fired but the corresponding Mission Timeline Reports contain none of the fire related events. This circumstance is reflected in the "unknown" NLT status. As Table 8 indicates, all those engagements where the NLT time was unequivocally not met were for dwell times of 30 minutes or less. Table 9 contains details of the 11 fired engagements with dwell times 30 minutes or less for which there was some information related to the mission fire time. This table reports the CE/LE accuracy of the mensuration as reported in LAWS. A value of 0/0, 100/100 or a blank indicates that the target was unmensurated. As the table shows, the only two cases (GS0091, GC0067) where the dwell times were 30 minutes or less in which the targets were judged to have been hit within their dwell times, appear to have been fired unmensurated. GC0067 was an ERGM mission and the firing of five ERGMs may represent an attempt to compensate for the absence of mensuration. But all five ERGMs were targeted at the same aim point.

TABLE 8

ENGAGEMENT NLT STATUS AS A FUNCTION OF DWELL TIME

DWELL	NLT met	NLT met?	NLT not met	Unknown	Not fired	Totals
10				1		1
20		1				1
30	2	1	7	5	12	27
60	2			6	2	10
90	13	1		2	4	20
120				3		3
>120	1			1	4	6
TOTALS	18	3	7	18	22	68
Columns:						
DWELL: NLT time - time received at LAWS rounded to nearest minute.						
NLT met: NLT - fire time >= 30 minutes for TTLAM/TLAM, >=10 minutes other weapons.						
Time in minutes to 120, for >= 120 minutes time in hours.						
NLT met ?: NLT - fire time >0 and < 30 minutes for TTLAM/TLAM, <10 minutes other weapons.						
NLT not met: NLT - fire time <=0.						
Uknown: Mission was fired but the LAWS Timeline Report contains no fire realted events.						
Not fired. Missions that were not fired						

TABLE 9

ALL FIRED ENGAGEMENTS WITH DWELL <= 30 MINUTES AND A LAWS REPORTED FIRE TIME

Dwell	Weapon	Firer	TGT #	Fire Time Source	CE/LE	NLT-Fire Time	Fired Cmd-LAWS	NLT Eval	Date	Remarks
30	TTLAM	DEYO	GM0055	OC	6/5	-13	42	N	28	
30	TTLAM	DEYO	GM5021	OC	0/0*	-14	43	N	28	
20	TTLAM	SAN JAC	GS0059	OC	8.3/8.2	12	7	?	28	
30	TTLAM	SAN JAC	GS0065	OC	14.2/11.9	20	9	?	29	
30	TTLAM	DEYO	GM5031	OC	6.2/5.6	-6	35	N	31	
30	LASM	SAN JAC	GS0084	FRD	18.1/17.1	-19	48	N	31	Fired 2 LASM
30	LASM/TTLAM	SAN JAC	GM5032	OC (FRD)	6.1/5.5	1 (-40)	28 (69)	N	31	Fired 1 LASM, 1 TTLAM
30	ERGM	SAN JAC	GS0085	WR (FRD)		20 (-14)	10 (44)	N	31	
30	ERGM	SAN JAC	GS0086	FRD	18.8/17.0	-1	30	N	31	
30	LASM	SAN JAC	GS0091	FRD		27	3	Y	31	
30	ERGM	DEYO	GC0067	WR	100/100*	16	13	Y	31	
Columns:										
Dwell: NLT time - time received at LAWS rounded to nearest minute										
Weapon: Weapon fired										
Fire Time Source: The LAWS timeline event equated to the fire time: FRD=Fired report,										
	WR=Fire When Ready command, OC=Fire On Call command.									
CE/LE: Circular Error/Linear Error. Mensuration accuracy reported in LAWS Targeting Information remarks.										
	*0/0 and 100/100 indicates target not mensurated									
NLT- Fire time. The interval between NLT and the event listed in column 5 rounded to the nearest minute.										
Fire Cmd - LAWS: The time of the fire command - the time the nomination was received by LAWS.										
NLT Eval: NLT evaluation from Table 4. N = NLT not met, ? = uncertain if NLT met.										
Date: Experiment day in August from which data came.										

11. RPM Data.

A single RPM workstation located in JTASC generated routes for all the TLAM and TTLAM missions. The RPM workstation automatically logged the time a route request was received and placed in a queue, the time route processing was initiated, the time it was completed and the time the completed route was transmitted to LAWS. The raw RPM data, provided by Michael Weissenberger (Boeing), have been analyzed and the results are presented in the Table 10.

TABLE 10

RPM ROUTE GENERATION TIMES FOR MTO AND TST TARGETS
(times in seconds)

	MISSION TYPE	
	MTO	TST
NUMBER OF MISSIONS	9	12
NUMBER OF ROUTES	32	14
MEAN TIME IN QUEUE	233.9	4.2
MEDIAN TIME IN QUEUE	105	2.5
MEAN TIME TO COMPUTE ROUTE	87.3	75.2
MEDIAN TIME TO COMPUTE ROUTE	85.5	76
MEAN TIME -RECEIPT OF REQUEST TO TRANSMIT ROUTE	321.5	79.9
MEDIAN TIME - RECEIPT OF REQUEST TO TRANSMIT ROUTE	177.5	80

The mean time required to compute a route for both MTO and TST missions was 83.6 seconds. The dispersion was small as indicated by the minimum and maximum intervals were respectively 65 and 115 seconds. The total time required to process a mission was predominately determined by the time the route request had to wait for processing in the queue. This in queue interval reached as high as 960 seconds. This large value occurred on 28 August when three MTO missions, each requiring four TLAMs to be fired, were processed. The RPM work load was exacerbated by requests for extraneous routes. The C4IGW operator reported (LAWS IRC channel August 28, 10:02) that "RPM is getting MPRs for the same routes multiple times". As an example, MTO mission GS0038 consisted of four TLAM firings but RPM generated nine TTLAM routes. Thus, least a portion of the RPM workload was spurious. Nevertheless, it appears it is not difficult to overload, a single RPM workstation, capable only of sequential mission processing and, consequently, significantly extend engagement timelines. In a few cases (all Deyo or Ale engagements on Aug. 31), there were no routes generated for TLAM engagements.

12. Digital target Folders (DTF)

The function of the DTFs are to serve as a repository of all information relating to TSTs. In FBE H the DTFs received input from the following sources:

GISRC	ATI.ATR
JTW	ATI.ATR
BDA	Manual input
CAST	creates link to preexisting target data.

12.1. TST DTFs

In FBE H, 128 TST DTFs were created. Deleting those DTFs created prior to the start of the experiment (31), a total of 96 DTFs were created during Phase I of FBE H. This number includes the MTO targets nominated by the San Jacinto GISRC (4) and duplicate DTFs (16). Excluding those, there are DTFs for 82 nominated targets. This is very similar to the number of targets nominated in LAWS, but the targets in the two lists do not closely correspond. There are 46 target numbers in LAWS that do not appear in the DTFs and there are 21 target numbers in the DTFs that do not appear in LAWS. The latter figure further conforms the evidence of GISRC and JTW that not all nominated targets appear in LAWS.

12.1.1. Mensuration data

The DTF was to be automatically updated with the ATI.ATR message that JTW sent to LAWS and the DTF with the mensurated target coordinates. This did not appear to work reliably in that only 13 of the DTFs reported Desired Mean Point of Impact (DMPI) data.

12.1.2. BDA Data

BDA was manually inserted into the DTF by setting the Target Status field. There were four states displayed in this field: Active, under engagement, attack completed, and destroyed. For the 82 FBE H Phase I DTFs, the number of DTFs reporting each of the four BDA states IS SHOWN IN Table 11.

TABLE 11
DTF TARGET STATUS

ACTIVE	24
UNDER ENGAGEMENT	18
ATTACK COMPLETED	16
DESTROYED	24
TOTAL	82

A comparison of specific nominations from LAWS and the DTFs indicates that the DTF Target Status is often not consistent with the LAWS engagement data. For example, in the LAWS data for 28 August there are six nominations which were not engaged but are listed as destroyed in the DTFs (GS0055, GM5020, GS0043, GS0044, GS0054, GS0037).

12.1.3 Data Time Tags

The DTF records the time the folder was created and the time of the last update. The DTF would be more valuable if each data element entered into the table were time

tagged. In particular, the DMPI data format provides a field named Time Mensurated but it was never filled.

12.1.4 Additional Data

The DTF is advertised as the repository of all relevant targeting data but there are many important gaps. There needs to be engagement data including: firing platform, weapon, time of fire, and impact time. Much more detail is required for BDA including time of BDA, source of BDA, and BDA sensor.

12.1.5 DTF Utility

The DTF folder was little used by FBE participants as a tool in the TST engagement process. This was in large part due to the inconvenience in accessing the DTF site for busy operators. Lack of DTF use presumably also owes something to the DTF data deficiencies described above.

12.2 Deliberate Target DTF

There were 289 DTFs for deliberate targets. After creation, these DTFs were never updated. They contain no BDA or mensuration data.

13. JSAF Data

In FBE H, none of the fire events for ERGM, LASM or TLAM for non virtual ships (e.g. San Jacinto and Deyo) were sent to JSAF. The San Jacinto and Deyo used ERGMs and LASMs to engage 77 percent of the TST targets. Accordingly, the great majority of TST weapons were not fired, flown out, or assessed in JSAF. The impact of this on the engagement timeline and, in particular, BDA is illustrated in Section 15.

14. MTO Missions

In FBE H, the LAWS Missions Coordination: Fires list contains some MTO missions in addition to the TST missions. The MTO missions, all assigned to the San Jacinto, were identifiable particularly on August 30 and 31 by remarks appearing in the LAWS Targeting Information identifying them as MTO targets. The other MTO targets were identified on the basis of the nominator (usually the San Jacinto LAWS) and the correspondence of the target location in the MTO with the target location reported in the LAWS Targeting Information.

Between August 28 and 31, 23 MTO engagements were assigned to the San Jacinto. Of those, 19 were nominated to LAWS by the San Jacinto LAWS or GISRC operators. Those that were not nominated lacked target positions in the MTO. Of the 19 targets nominated 11 were fired on. The reasons for engagement denial were listed in LAWS for

six of the eight targets that were not engaged, they included 4 RNG (range), 1 INT (intelligence), and 1 TIW (target in water). Other remarks in LAWS indicated the target positions were erroneous for the INT, TIW and one of the RNG missions. The MTO targets were not mensurated, this is explicitly stated in the LAWS remarks for some of the MTO targets (e.g. GS0038, GS0039, GS0040). Lack of mensuration is also indicated by the fact that the MTO target coordinates were almost always reported with zero seconds.

Operationally, the San Jacinto would fire its few MTO missions (from one to four) the first thing each day and then spend the rest of the day on TST targets. There was no interaction between the MTO and TST processes.

15. Data Latency

On August 31 Richard Tanner (INRI) made manual measurements of the interval it took for a track entered at the MTW or HST to appear on GCCS-M or C2PC displays at JTASC and vise versa. Fourteen observations produced intervals ranging from 1.8 to 9 seconds with mean and median of 3.9 and three seconds respectively. Although quantitative measurements were not made for other data latencies, a number of reports indicate that, at times, significant latencies existed for UAVSim video transmitted to GISRC and for communication of LAWS updates between the LAWS workstations. In constructing timelines for several engagements, in two cases (GH0209 and GH0210) it was found that it took more than 50 minutes for the nominations to reach LAWS and JTW from GISRC. Characterizing the magnitude and frequency of significant latencies in communications between systems in the DFN requires more complete electronic data capture by the various DFN systems and accurate time synchronization of those systems.

16. A Timeline Example

Table 12 presents a timeline for the engagement of target GM5032. This engagement timeline is comparatively complete and demonstrates the information potential of timelines. It also illustrates some of the problems the available data present in the construction of a complete and accurate timeline.

This mission was fired by the San Jacinto on August 31. The mission is listed in the LAWS Mission Coordination: Fires display as a LASM mission but the target was first engaged with a TTLAM and subsequently a LASM. Both weapons were fired under the same target number. LAWS does not retain timeline data for multiple weapons fired with the same target number. Both the TTLAM and LASM firings are reported in the LAWS Mission Coordination: TLAM display but, unfortunately, the fire times were not reported there.

The LAWS data indicate the target was mensurated but the JTW data were not collected on the San Jacinto and the San Jacinto JTW was not able to transmit ATI.ATR messages to the San Jacinto LAWS, accordingly, JTW timeline information is missing.

The timeline exhibits the following inconsistencies and problems:

1. The LAWS Timeline Report indicates the nomination was received at LAWS 45 seconds before GISRC reported it sent.

2. The San Jacinto LAWS smtp_out log indicates the Mission Planning Request (MPR) was sent to the RPM 139 seconds after it was received, as logged by the RPM, and 60 seconds after the San Jacinto LAWS smtp-in log indicates the completed route was received from RPM.

3. The RPM log indicates the route data were transmitted one second after they were received according to the San Jacinto LAWS smtp_in log.

4. The LAWS Timeline Fired Report for the LASM is time tagged about 20 minutes after the time of launch as indicated by the information in the San Jacinto observer log and IRC GISRC channel.

5. IRC and San Jacinto observer logs indicate the LASM was fired prior to 1400. TOF would only have been a few minutes but BDA did not occur until 1431. The need to manually impose target assessment and BDA (because the LASM firing was not sent to JSAF) required the UAV loitering in the target vicinity for about 30 minutes after the actual impact time.

The excerpts from the IRC GISRC channel that appear in Table 12, relate to the tasking of a UAV to obtain BDA for GM5032. The GISRC channel communications do not refer to a target number, only the target coordinates, accordingly the relevance of these data is circumstantial but they appear consistent with the timeline events.

TABLE 12

ENGAGEMENT TIMELINE FOR TARGET GM5032

TIME (hhmmss)	EVENT/REPORT	SOURCE
130005	ACQUIRE	MTW GISRC LOG
130027	NOMINATE	MTW GISRC LOG
130738	SEND	MTW GISRC LOG
130653	RECEIVED BY LAWS	LAWS TIMELINE
133322	MPR RECEIVED BY RPM	RPM LOG
133323	STARTED TO CREATE ROUTE	RPM LOG
133441	ROUTE RECEIVED FROM RPM	SAN JAC LAWS SMTP_IN LOG
133442	TRANSMITTED ROUTE TO LAWS	RPM LOG
133445	XMT OC FIRE COMMAND	LAWS TIMELINE
133541	MPR TO RPM	SAN JAC LAWS SMTP_OUT LOG
133730	TLAM ROUTE TO JSAF	MTW LAWS SMTP_OUT LOG
133833	INDIGO FIRING REPORT TO JSAF	MTW LAWS SMTP_OUT LOG
1338XX	FIRE TLAM, TOF 10 MINS.	SAN JAC OBSERVER LOG
1339XX	TLAM AWAY, TOF 10 MINS	IRC LAWS CHANNEL
1346XX	TLAM IMPACT, AWAIT BDA	IRC LAWS CHANNEL
135142	BDA= NO EFFECT, REENGAGE	LAWS COMMO LOG
1351XX	RETARGET, FIRE LASM	SAN JAC OBSERVER LOG
141628	FIRED REPORT	LAWS TIMELINE
1431XX	TARGET DESTROYED	IRC GISRC CHANNEL
TIME (hhmm)	**IRC GISRC CHANNEL COMMUNICATIONS (GM5032)**	
	(LAWS coordinates for GM5032 are 34 33 57.7N, 77 16 38.7 W)	
1329	<MTW_GISR2> #5, please investigate 34 39 56N/077 20 38W, possible movement/staging area	
1326	<MTW_GISR2> #5, what do you have?	
1338	<UAV_5-6> MTW-GISR, traffic in vicinity of 34 35N 77 17W, but looks all civilian	
1338	<MTW_GISR2> #5 can you fly closer for a better look	
1340	<UAV_5-6> roger	
1342	<MTW_GISR2> #5 need BDA on 3 sets of targets visited earlier vicinity 34 34N/ 077 15W	
1342	<UAV_5-6> roger, UAV5 going for BDA	
1346	<UAV_5-6> MTW-GISR, uav5 looking at previous targets vicinity 34 34N 77 15W	
1347	<MTW_GISR2> roger, negative BDA	
1348	<MTW_GISR2> #5 those targets will be reattacked.	
1349	<UAV_5-6> MTW-GISR, roger, standing by for BDA	
1354	<UAV_5-6> MTW-GISR, those targets remain undamaged	
1355	<MTW_GISR2> roger #5, stay on them	
1357	<UAV_5-6> uav5 keeps eyes on target	
1358	<MTW_GISR2> #5, San Jac and Deyo LASMs should be inbound	
1358	<UAV_5-6> roger, watching	
1404	<UAV_3-4> standby on BDA - these recent weapons all need manual eval - lots of concurrent evals now	
1407	<UAV_5-6>MTW-GISR, did you copy #3 message on manual BDA process? Bottom line, standby	
1430	<UAV_5-6> MTW-GISR, uav5 is still standing by, you should get some BDA soon	
1430	<MTW_GISRs> roger #5	
1431	<UAV_5-6> MTW-GISR, uav5 reports all 3 sets of vehicles destroyed vic 34 35N 77 15W	

17. Electronic Data Capture in FBE H

In FBE H, improvements were made in the collection and reporting of electronic data, particularly for GISRC and RPM. Much however, remains to be done particularly with regard to LAWS and JSAF which are central to the TST process in FBEs. Table 13 summarizes those events for which it was attempted, or would have been desirable, to collect data in FBE H, the success of the effort and reasons for lack of success. In addition to capturing the events and their associated data elements, the discussions in this document illustrates the problems with, and the importance of, the synchronization of the time stamping for all systems.

TABLE 13
ELECTRONIC DATA CAPTURE IN FBE H

SYSTEM	EVEN T	COLLECTED	SOURCE	REMARKS
LAWS	receipt of nomination	Y	LAWS Timeline	
LAWS	update latency	N		time required for update to be displayed at each LAWS node
LAWS	receipt of mensuration data	N		not in LAWS Timeline
LAWS	request TLAM route	Y	LAWS smtp_out logs	should be in LAWS Timeline
LAWS	receipt of TLAM route	Y	LAWS smtp_in logs	should be in LAWS Timeline
LAWS	TGT action	P	LAWS Timeline	not reliably present
LAWS	fire command	P	LAWS Timeline	not reliably present
LAWS	acknowledge fire command	N		not in LAWS Timeline
LAWS	fired report	P	LAWS Timeline	not reliably present
LAWS	TTLAM retargeting	Y	LAWS smtp_out logs	should be in LAWS Timeline
LAWS	estimated TOT	N		not in LAWS timeline
LAWS	NLT time	P	LAWS Targeting info	Dwell not entered for LAWS nominated targets. Should be in LAWS Timeline
JSAF	target injection	N		JSAF needs to be modified to log this event.
JSAF	target sensed	N		JSAF needs to be modified to log this event.
JSAF	target change of state	N		JSAF needs to be modified to log this event. Includes moving/stationary, hide/unhide
JSAF	weapon fire	N		majority of fire events not sent to JSAF. FBE AARS not operational
JSAF	weapon impact	N		majority of fire events not sent to JSAF. FBE AARS not operational
GISRC	receipt of target cue	N		not in GISRC logs. Require manual collection?
GISRC	cue follow up command	N		not in GISRC logs. Require manual collection?
GISRC	target acquisition	P	GISRC logs	data not complete for all platforms
GISRC	image latency	N		not in GISRC logs. Require manual collection?
GISRC	target nomination	P	GISRC logs	data not complete for all platforms
GISRC	transmit target nomination	P	GISRC logs	data not complete for all platforms
JTW	receipt of mensuration request	P	JTW logs	data not collected on all platforms. Not electronic, manually collected
JTW	transmit mensuration data	P	JTW logs	data not collected on all platforms. Not electronic, manually collected
JTW	time to mensurate	P	JTW logs	data not collected on all platforms. Not electronic, manually collected
RPM	receipt of route request	Y	RPM logs	
RPM	transmit route request	Y	RPM logs	
RPM	time to calculate route	Y	RPM logs	
CST	track latency	P	manual log	CST electronic logging not employed. Data consist of a few manual observations
IRC	communications	Y	IRC logs	Time tagged chat channels to integer minutes. Need time tag to integer seconds
		P = partial		

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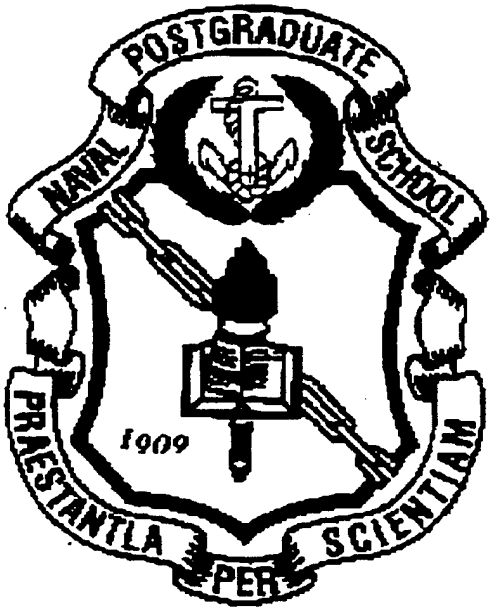

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